

EXPLANATION OF PLATE XI.

- Fig. 1. *Bairdia Jonesiana*, n. sp. : right valve ; magnified 30 times.  
 Fig. 2. *Bairdia Jonesiana*, a less elongate form : right valve ; magnified 30 times.  
 Fig. 2 a. *Bairdia Jonesiana* : lateral contour.  
 Fig. 3. *Bairdia rhomboidea*, n. sp. : right valve ; magnified 26 times.  
 Fig. 3 a. *Bairdia rhomboidea*, lateral contour.  
 Fig. 4. *Bairdia truncata*, n. sp. : east of right valve ; magnified 38 times.  
 Fig. 4 a. *Bairdia truncata*, lateral contour.  
 Fig. 5. *Leperditia? Permiana*, Jones : right valve, having a smooth surface ; magnified 26 times.  
 Figs. 6 & 8. *Leperditia? Permiana* : right and left valves, showing a wrinkled surface ; magnified 26 times.  
 Fig. 7. *Leperditia? Permiana* : left valve of a specimen with a punctured surface ; magnified 30 times.  
 Fig. 9. *Leperditia? Permiana* : left valve of a young specimen ; magnified 38 times.  
 Fig. 10. *Leperditia? Permiana* : ventral aspect of a specimen showing lateral compression and marginal rims ; magnified 26 times.  
 Fig. 11. *Leperditia? Permiana* : ventral aspect of a more globose specimen, showing marginal rims, punctured ; magnified 30 times.  
 Fig. 12. *Leperditia? Permiana* : dorsal aspect of the last specimen ; magnified 30 times.  
 Fig. 13. *Leperditia? Permiana* : interior of right valve ; magnified 30 times.

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XLVII.—*Investigation of the Generative Organs and Reproduction of the Infusoria.* By M. BALBIANI\*.

IN a preceding communication† I had the honour of communicating to the Academy some of the results at which I had arrived in studying the reproduction and development of the Infusoria called Polygastrica in the classification of Ehrenberg. In the course of the present spring and summer I have been able to extend my researches to several other species, and to complete some old observations which the want of materials had compelled me to interrupt for a time. The object of the present note is to make known the most essential of these new results, the detailed exposition of which will form the subject of a memoir which I propose shortly to submit to the Academy.

The investigation of the propagation of *Paramecium Bursaria* had led me to assume in this species, independently of a multiplication by spontaneous scission, a second mode which constituted a true sexual generation, and to recognize in the organs described under the names of *nucleus* and *nucleolus* the analogues of the male and female generative organs of the higher animals.

\* Translated from the 'Comptes Rendus,' 30 August, 1858, p. 383, by W. S. Dallas.

† See 'Annals,' 3rd series, No. 6. p. 435.

I had also been led, in a great number of cases, to regard what nearly all authors had considered to be a spontaneous division in a longitudinal direction, as a sexual union of two individuals. Very often, in fact, I have been able to ascertain that this state coincided with certain remarkable changes which took place in the internal organs of these animals.

I. The corpuscle which, in the Infusoria, has been described under the name of nucleolus, and which I have shown to be the male genital gland, has hitherto only been indicated in a few rare species. In connexion with this, I have examined a great number of individuals belonging to numerous and varied forms, and I have convinced myself that, far from constituting an exception, the presence of one or even several nucleoles was a nearly constant fact in the different types of this class; but frequently the simple or multiple nucleole which they contain is so intimately confounded with the substance of the nucleus, that it only becomes apparent when it is separated therefrom accidentally by the action of reagents, or spontaneously at certain determinate periods in the life of these creatures, principally at the time of their sexual propagation. I have counted fourteen species in which this organ was very evident to me, and in which I have also been able to follow its evolution, to a greater or less extent, at the breeding season, at the same time that I was an eye-witness of the other actions which concur in assuring the reproduction of these animalcules by fecundated germs.

As regards the number and situation of the testicular organ of the Infusoria, I have met with the following varieties. It is simple, rounded, and lodged in more or less deep depressions of the nucleus in *Paramecium Aurelia* and *P. caudatum*, and also in a third species nearly allied to *P. Bursaria*, but smaller and destitute of green granules. The genus *Bursaria* (*B. leucas*, *flava*, and *vernalis*) also presents a simple nucleole situated in the vicinity of the nucleus. The same thing occurs in *Chilodon cucullulus*. But with regard to the latter, I must remark that I do not regard as the analogue of the nucleole of the preceding species the corpuscle to which M. von Siebold has given this name, and which is placed in the interior of the granular mass of the nucleus, in the centre of a broad transparent zone. The true nucleole or testicle of *Chilodon* appears in the form of a small, rounded, brilliant grain, provided with a proper membrane, and situated quite to one side and towards the middle of the nucleus. It is very easily perceived in large specimens by employing the action of reagents. As regards the nucleus and its internal parts, I make no difficulty in regarding them as representing all the elements of an ovum, of which the nucleole of the celebrated German naturalist would be nothing but the germinal spot. The

disappearance of the clear zone and of its central corpuscle in the animals which have just copulated, especially appears to me to militate in favour of this view.

II. I have met with a multiple testicle in many species belonging to the groups of the *Oxytrichinæ* and of the *Euplotes* or *Plascomiæ*, including the highest types of this class. In the genus *Oxytricha* the two nuclei, which are elongated in the direction of the greater axis of the body, are each accompanied by a small, rounded, testicular body, very distinct from the corresponding nucleus. There are also two, placed one to the right and the other to the left of the long nucleus, which is curved into the form of a horse-shoe, in *Euplotes Charon* and *viridis*. In the genera *Stylonychia* (*S. Mytilus*, *pustulata*, and *lanceolata*) and *Urostyla* (*U. grandis*), the nucleoles, to the number of four or five, are distributed in two groups in the vicinity of the nuclei, of which the anterior is accompanied by two, and the posterior also by two or sometimes three of these little organs. They are remarkable from their distinctly rounded outline, their great refractive power, and their homogeneous structure. In *Spirostomum ambiguum*, each of the grains of the long moniliform cord which here replaces the oval nucleus of the other species, gives lodgment, in a deep depression of its surface, to a small rounded corpuscle, which corresponds with the nucleole of the preceding species; this brings the number of testicles in this animal to forty-five or fifty. I have only been able to perceive them in individuals which have been copulating for a certain time, and by employing dilute acetic acid. It is very probable that an analogous arrangement will be found in the other types in which the nucleus is formed of grains placed in a single row, like a necklace, such as *Stentor*, *Kondylostomum*, *Trachelius moniliger*, &c.

III. The evolution of the male genital apparatus of the Infusoria, as just characterized, in the other species of the genus *Paramecium* does not differ from that presented to us by *P. Bursaria*. In the *Oxytrichinæ* each of these organs remains entire, becomes enlarged, and exhibits in its interior, applied against its wall, a thick granular body, furnished with a tubular appendage, which projects into the cavity of the capsule, and appears to be open at its free extremity. This tube, which seems to be an excretory duct, often appeared to be filled with capillary filaments of extreme fineness, arranged parallel to the axis of the duct in question, in which they were fixed by a portion of their length, whilst the remainder, escaping by the orifice of the tube, radiated in all directions in the interior of the capsule. Subsequently the granular body and its duct disappear, and the filaments, becoming free, collect into a bundle, which fills the

whole of the formative sac. Although I have never seen them execute any movements, I do not hesitate in considering them as the spermatic filaments of these animals.

IV. It is with equal certainty that we may call the *nucleus* the female genital organ of the Infusoria, in opposition to the perfectly hypothetical assertion of Ehrenberg, who regards it as the testicle. Its evolution likewise only commences at the time of reproduction, and often during the sexual union itself. In *P. Aurelia* and *caudatum*, towards the end of the copulation, its surface is traversed in all directions by numerous furrows, which, penetrating deeper and deeper into its mass, finally divide it into a great number of unequal and irregularly rounded fragments, having a clear centre more or less surrounded by granules. I should compare these with the first rudiment of a vitellus, and the transparent central portion to a more or less developed germinal vesicle. The fragments thus formed are soon dispersed in the surrounding parenchyma. Here a very small number of them, almost always four, never more and very rarely less, complete their evolution, and soon acquire the appearance of complete and well-developed ova. In this state they present themselves in the form of small brilliant bodies, perfectly equal in volume, slightly oval, and of a bluish-grey appearance. We may very clearly distinguish in them a finely granular vitellus, surrounded by its proper membrane, which separates from it more or less after a few moments' exposure to water. The germinal vesicle and spot are also visible with a distinctness truly surprising, considering that we have to do here with the smallest of living organisms. I have met with these ova still enclosed in the body of the animal on the seventh day after the copulation; they no longer exhibited either germinal vesicle or spot, and their volume had slightly increased. In the allied species, *P. Bursaria*, the reniform nucleus becomes unrolled before breaking up, and in this state resembles the ribbon-shaped nucleus of the *Vorticellæ*. About twenty or twenty-five of the fragments produced from it continue their development and become so many perfect ova. In the nucleus of *Chilodon cucullulus*, also, we observe, after the copulation, the disappearance of the transparent zone with its central obscure spot. In the genera *Stylo-nychia* and *Urostyla* the ova are four in number, as in *Paramecium caudatum*, but they are produced by a different mechanism. Each of the two nuclei divides into two halves, as in the act of spontaneous division; and the four fragments thus produced form an equal number of perfect ova. Lastly, in *Spirostomum ambiguum*, we have seen, in individuals which have been copulating for some time, the forty or fifty grains of the long flexuous cord which traverses the body become rounded and detached from

each other. But we have been unable to discover in these all the characters of an ovum with the same distinctness as in the preceding species, no doubt because they had not yet arrived at their complete development.

V. I have not witnessed the *deposition of the ova* in these animals. It is very probable that they escape by the anus, or by some neighbouring aperture. Thus, in the *Stylonychia*, I have seen them collect in the posterior part of the body which bears the anal orifice, and diminish gradually in number from the first or second day after the copulation. It is a singular thing, that about this period a round pale body begins to make its appearance in the centre of the animal; this becomes constricted about the middle, and reconstitutes the double nucleus of *Stylonychia*.

VI. The Infusoria are destitute of copulatory organs. In most cases the copulation is effected by simple juxtaposition, the two mouths establishing the sexual communication (*Paramecium*, *Bursaria*, *Euplotes*, *Chilodon*, *Spirostomum*). In the *Oxytrichinae* the union is more intimate, and goes so far as to constitute a true soldering of the two individuals for more than two-thirds of their anterior part. Any one who had not witnessed all the phases of this singular copulation, would be unable to avoid regarding this state as a longitudinal division, proceeding from behind forwards, in a single animal. But even, if direct observation were wanting, the concomitant changes of the internal organs, which are so characteristic, cannot leave the least doubt as to the actual signification of this act.

XLVIII.—*Remarks on certain Vermiform Fossils found in the Mountain Limestone Districts of the North of England.* By ALBANY HANCOCK\*.

[With six Plates.]

IN 1838, Mr. Dixon Dixon, of Unthank, presented to the Newcastle Museum a few slabs of a fine-grained micaceous sandstone, which were procured from a quarry on Haltwhistle Common. These slabs exhibited on their surfaces peculiar elevated and depressed markings, supposed at the time to be either the fossil remains of worms, or casts of worm-tracks.

Slabs bearing similar markings were likewise obtained by Mr. Edward Wood, of Richmond, in 1850, from the same formation in Wensleydale, Yorkshire, and were described by that gentleman in two interesting communications published in the

\* Communicated by the Author, having been read at the Meeting of the British Association held at Leeds, September 22, 1858.